



**TITLE: METHOD AND COMPOSITION FOR CONTROL OF MICROBIAL  
CONTAMINATION IN DRINKING WATER PRODUCED BY  
CONDENSATION.**

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**Field of the Invention**

The present invention relates to methods and compositions suitable for the treatment of drinking water collected from condensation so as to reduce the microbial contamination while preserving the potability of the water. More specifically, a simple, inexpensive method and composition are provided for reducing microbial contamination of drinking water produced from condensation which preserves the taste and potability of the water while being capable of simple unattended operation.

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**Background of the Invention**

Methods of producing high quality drinking water in a portable unit by condensation of dew from ambient air are well known in the art. For example, U.S. Pat. No. 5,669,221 issued to LeBleu et al on September 23, 1997 and U.S. Pat. No. 5,845,504 issued to LeBleu on December 8, 1998 teach a portable non-attended potable water generator enclosed in a decorative case. U.S. Pat. No. 5,553,459 issued to Harrison on September

10, 1996 similarly teaches a water making apparatus which produces potable water from the moisture in atmospheric air.

One of the more troubling problems with producing high quality drinking water from condensation, yet one of the most important, concerns the control of microbial contamination. Without satisfactory disinfection of drinking water numerous problems can result. For example, the typhoid and cholera epidemics which were common throughout American cities in the last century were caused by poor disinfection. EPA's Science Advisory Board concluded in 1990 that exposure to microbial contaminants such as bacteria, viruses, and protozoa (e.g., *Giardia lamblia* and *Cryptosporidium*) was likely the greatest remaining health risk management challenge for drinking water suppliers.

It has also been recently learned that there are specific microbial pathogens, such as *Cryptosporidium*, that are highly resistant to traditional disinfection practices. In 1993, *Cryptosporidium* caused 400,000 people in Milwaukee to experience intestinal illness. More than 4,000 were hospitalized, and at least 50 deaths have been attributed to the disease. There have also been cryptosporidiosis outbreaks in Nevada, Oregon, and Georgia over the past several years. Because of these problems disinfection has long been recognized as an essential part of the art of producing drinking water.

There are currently two main commercial ways of treating microbial contamination in drinking water.

Chlorine is the standard form of treatment used in municipal systems.

However, chlorine is a toxic substance and must be used under strict controls which would be difficult to implement in a portable, non-attended device. It also imparts a bad taste to water, and can react with naturally-occurring materials in the water to form unintended organic and inorganic byproducts which may pose health risks. Stronger oxidizing agents than chlorine can also be used such as ozone or iodine, but these are also difficult to implement, may impart bad tastes, and can cause the formation of halogenated organics.

- 10 Ultraviolet (UV) lights have become the main treatment method for rural residential and commercial systems, and the previously referenced patents to LeBleu and Harrison teach the control of microbial contamination in water collected from condensation by employing a bacteriostatic loop employing UV light. UV light has a number of practical difficulties, however, such as the
- 15 difficulty of determining the correct size of the UV light and problems associated with contamination. Levels of hardness, iron, manganese, humic and fomic acid, tannins and other materials must be minimal to avoid staining on the lamp's internal sleeve which can shield bacteria from the UV rays. Most importantly, UV lights have been found in practice to be
- 20 ineffectual for use with water produced from condensation. Although the failure mechanism is not precisely known, it is perhaps because the pathogens involved are dissimilar from those found in natural water where UV light has been found to be more effective.

In addition to the methods of disinfection which rely on chlorine or UV light, a number of other methods of disinfection have been proposed. The use of filtration has been proposed, as discussed in US Pat. No. 3,242,073, although this would not be practical in an unattended device.

- 5 The use of electrical water purification using an ionization chamber or chambers and electrodes of various alloys, including silver and copper, has been proposed to control algae and bacteria. Prior patents dealing with the problem of electrical water purification include U.S. Pat. No. 4,525,253 issued to Hayes et al on June 25, 1985. Hayes et al teaches the use of electrodes of
- 10 a copper/silver/nickel alloy. The reference, which is contemplated mainly for swimming pools and other outdoor water storage areas, is directed to removal of algae and bacteria without the use of chlorine; however, the presence of silver in drinking water may lead to health problems. Like the previous Hayes et al reference, U.S. Pat. No. 4,680,114 issued to Hayes on
- 15 July 14, 1987 and U.S. Pat. No. 6,207,060 issued to McKay on March 27, 2001 teach the use of silver and copper/silver alloyed electrodes, or copper or zinc electrodes. U.S. Pat. No. 4,263,114 and 4,328,084 issued to Shindell disclose the use of electrodes to destroy organic matter, especially in swimming pools and spas. However, the addition of excess sodium to
- 20 drinking water may be detrimental to human health.

Treatment of household drinking water by passing the water through a bed of activated charcoal impregnated with or having oligodynamic silver or other bactericide adsorbed thereon is known from the prior art. For example, U.S.

Pat. No. 2,595,290, patented May 6, 1952, U.S. Pat. No. 3,242,073 patented Mar. 22, 1966, U.S. Pat. No. 3,268,444, patented Aug. 27, 1968, U.S. Pat. No. 3,585,130, patented June 15, 1971, and the references cited therein.

In addition, the United States National Aeronautics and Space Administration  
5 (NASA) has conducted experiments and constructed apparatus for treating spacecraft water with silver ions for biocidal and virucidal purposes.

Reference to this work is cited in US Patent No. 4,198,296, and teach the biocidal virucidal effects of silver ions in a very pure distilled or deionized water.

10 There is a need for a simple, inexpensive method and composition for reducing microbial contamination of drinking water produced from condensation. Such should preserve the taste and quality of the water while being inexpensive and capable of simple, unattended operation.

## 15 **Summary of the Invention**

It is an object of the present invention to provide a method and composition which simply and inexpensively reduces the microbial contamination of drinking water produced from condensation while preserving the taste and  
20 quality of the water. The apparatus produces biologically safe and palatable drinking water from condensate by contacting the water with a biocide in an apparatus designed to reduce contamination to acceptable levels. The biocide is a disinfectant composition made from a zeolite which is subjected

to hydrothermal ion exchange modification to produce a material capable of controlled release of zinc ions.

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**Brief Description of the Drawings**

Figure 1 is a diagrammatic view illustrating the flow process of an apparatus in accordance with the teaching of the invention.

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Figure 2 shows the performance of the ion exchange process.

Figure 3 shows the performance of the biocide composition in NaCl solution.

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### **Detailed Description of the Invention**

While this invention may be embodied in many different forms, there are described in detail herein specific preferred embodiments of the invention.

The descriptions are an exemplification of the principles of the invention and

5 are not intended to limit the invention to the particular embodiments illustrated.

With reference to the drawings, Fig. 1 illustrates a general schematic

illustration of one embodiment of the instant invention consisting of a closed

10 loop water treating system which includes a dehumidifier **060** which produces water from condensation of air which is collected in a bottom tank **010**.

When the bottom tank **010** is full, the magnetic level control **080** will send a signal to the microprocessor **070** which in turn will send a signal to activate the pump **020**. From the bottom tank **010** the water is pumped thru the

15 biocide **030** and then the water is delivered to the top holding tank **040**. A level control **090** will detect when the tank **040** is full, whereupon the level control **090** will send a signal to the microprocessor **070** to stop the pump

**020**. The microprocessor **070** sends a signal every six hours to the recycling valve **050** to recycle the water from the top holding tank **040** to the bottom

20 tank **010** to prevent growth of bacteria in the water. The conductivity sensor **100** may be any commercially available device well known in the art which measures the conductivity of the water such that if the quality of the water

changes, the output of the conductivity sensor **100** will change, and the

microprocessor **070** will detect the change in the conductivity sensor **100** and

will stop the pump **020** and send an alarm signifying that the quality of the water may not be safe for consumption.

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### **Description of the Biocide**

In a preferred embodiment of the present invention the biocide consists of a zeolite which is specially treated to induce biological activity, as described  
10 below.

The zeolite can be any zeolite selected from among those which are well known in the art. In a preferred embodiment the zeolite is clinoptilolite, a naturally occurring volcanic mineral, which is a hydrated aluminosilicate  
15 with infinite three-dimensional frameworks of silicon-oxygen (SiO<sub>4</sub>) tetrahedra. The material is available from Bompahi Mexico City mined at a deposit in Coahuila Mexico. The zeolite contained in the mineral is a clinoptilolite – heulandite, hydrated aluminum silicate which chemical composition is

20  $(\text{Na}_{1.84} \text{K}_{1.76} \text{Mg}_{0.2} \text{Ca}_{1.24})(\text{Si}_{29.84} \text{Al}_{6.16} \text{O}_{72}) \cdot 21.36 \text{H}_2\text{O}$

Mineralogical composition : Ca - K - Na - hydrated aluminosilicate



### Mineralogical analysis (XRD)

Clinoptilolite min. 75 %

(Calcium-Potassium-Sodium type, Si/Al 5.4) with minor feldspar

(5 %) and montmorillonite (4 %)

5 Pore volume : 0.34 cm<sup>3</sup>/cm<sup>3</sup>

### Physical properties (typical)

Specific density	1,4 – 1,6 g/cm <sup>3</sup>
Bulk density	0,6 – 0,8 g/cm <sup>3</sup>
Hardness	3.5 - 4 (Mohs scale)
Alkaly stability	7 - 11 pH
Acid stability	7 pH
Moisture content	<2
Absorbing gases	NH <sub>3</sub> , H <sub>2</sub> S
Colour	Greenish, Gray

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### Preparation and Activation

#### Screening

In a preferred embodiment the zeolite is first screened to produce a desired

15 particle size. In one embodiment particle sizes of less than 0.091 mm are selected. In another embodiment particle sizes of between 1 and 3 mm are

selected. In yet another embodiment particle sizes of 3 to 10 mm are selected.

### **Purification**

- 5 In one embodiment following screening the zeolite is purified by washing with distilled water at a temperature of from 115 to 120 degrees F following which the pH is measured and adjusted as necessary to 7.0 by the addition of any nontoxic acid or base. This process is repeated from 1 to 5 times.

### **10 Activation**

In a preferred embodiment the zeolite is activated by hydrothermal ion exchange modification which imparts zinc ions into the structure of the zeolite.

In one embodiment the previously described clinoptilolite is treated by boiling in a solution of  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  for a period sufficient to incorporate sufficient

- 15 zinc into the clinoptilolite. The actual concentration of  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  is selected from within the range of 1 to 10 % by weight of  $\text{ZnSO}_4 \cdot \text{H}_2\text{O}$  so as to be sufficient to impart the desired biological activity while minimizing the concentration of zinc in the finished water and preventing staining of the apparatus. The boiling time may be from 2 hours to 15 hours. In a preferred  
20 embodiment the boiling time is 10 hours.

### **RESULTS**

## Ion exchange properties

A chemical analysis showed that zinc exchanges with calcium in the clinoptilolite even though the selectivity of this zeolite is lower for zinc ions.

- 5 However, the hydrothermal conditions established for the exchange reaction increase the zinc incorporation to the clinoptilolite structure.

The release of Zn from the biocide was studied in two different systems: 1) a drinking water system, and 2) a NaCl (0.9%) dissolution (pH 5.8) to approach  
10 a simple biological media.

Figure 2 shows the measured performance of the different cat ions in the exchange process of the biocide when the biocide was placed in a column containing a 20-cm-long bed of biocide, with diameter of 2 cm, and drinking  
15 water was passed through. The ion exchange study showed that  $\text{Zn}^{2+}$  ions are mainly exchanged from the biocide by  $\text{Ca}^{2+}$  and in lower proportion by  $\text{Na}^{+}$  ions present in water. The amount of Zn released from the clinoptilolite structure to the drinking water was lower than 10 ppm, which meets the typical requirement for drinking water. This Zinc content suffices to produce a  
20 bactericide effect.

An exchange study using a NaCl dissolution demonstrated that it is the clinoptinolite that controls the release of Zn ions from the biocide. Figure 2 shows the plot of Zinc content in the NaCl dissolution vs. exchange time after

the contact between the biocide and NaCl dissolution and the velocity of Zn ions release from the biocide. The plotting was adjusted to the Higuchi model confirming the controlled released of Zn ions by the zeolitic material.

## 5 Biological Properties

A study was conducted using the biocide of the instant invention. Table 1 shows the results of a microbiological test conducted using drinking water -- without chlorine-- contaminated with Escherichia coli ATCC 25922. Notice how  
10 the number of colony unit formation was reduced within the first 2 to 5 hours of contact with the biocide and without stirring the system. A comparison of the biocide and chlorination treatments showed that the biocide is equally effective for the elimination of microbiological contamination.

	COLONY UNIT FORMATION		
Time [hours]	Biocide [0%]	Biocide [5%]	Biocide [10%]
0	81 x 10 <sup>3</sup>	1 x 10 <sup>2</sup>	5 x 10
2	10 x 10 <sup>3</sup>	8 x 10	5 x 10
5	29 x 10 <sup>3</sup>	10	5
24	71 x 10 <sup>3</sup>	80	10
48	92 x 10 <sup>3</sup>	89 x 10 <sup>2</sup>	3 x 10 <sup>2</sup>

Table 1. Bactericide effect of biocide of instant invention against *Escherichia coli* ATCC 25922 in drinking water

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## CONCLUSIONS

- 10 The results obtained in all the studies lead to the main conclusion that the instant invention provides a controlled release of zinc ions to the biological media and water, and has the desired disinfectant result. A chemical analysis of the activated clinoptilolite indicates that zinc exchanges with the naturally occurring calcium even though the selectivity is lower for the zinc ions.

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## **Experimental Analysis**

An evaluation of the invention was performed to test its effectiveness and efficiency by installation on a commercially available unit, a Model No. LA1  
5 available from Liquid Air, 249 E. Ocean Blvd., Ste. 1010 , Long Beach, California 90802. The tested unit consists of a portable, potable-water generator for producing high-purity liquid water by condensation of dew from ambient air. An enclosed heat absorber cools the filtered air below its dew point and collects droplets of condensate into a closed system. The collected  
10 liquid dew is further treated in a bacteriostatic loop consisting of a UV light to destroy living organisms followed by a carbon filter and 1 micron filter. The water is recycled through the bacteriostatic loop every 3 hours.

### **Example 1**

15 The test unit equipped with the standard UV light system followed by a carbon filter and 1 micron filter was placed in an environment simulating that of a typical home and observed for a period of time, with the following results.

3/27/03: Unit placed in service.

3/16/03: Water tanks observed to be contaminated with slime and algae. Unit  
20 replaced.

5/21/03: Water tanks again contaminated with slime and algae. Unit replaced.

6/23/03: Water tanks again contaminated with slime and algae. Unit replaced.

6/30/03: Test unit was modified to include the present invention in place of the UV light, Carbon filter and 1 micron filter, (the UV light, Carbon filter, and 1 micron filter were removed) and the system was placed in service in the same environment, with the following results:

No slime or algae was observed and the following measurements were obtained:

10	DATE	HETEROTROPHIC PLATE COUNT
	7/3/03	NA
	7/7/03	NA
	7/8/03	NA
15	8/4/03	NA
	8/5/03	2
	8/11/03	5
	8/25/03	7
	9/15/03	1

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## Example 2

A test unit similar to that described in Example 1 equipped with the standard UV light, carbon filter and 1 micron filter was placed in a typical office environment (temperature 74 to 78 degrees F., humidity 44 to 56 %). The unit was placed in service on 6/28/03 with the following results:

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DATE	HETEROTROPHIC PLATE COUNT
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7/3/03	108000
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10 7/8/03	32000
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7/8/03	35680
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The test unit was modified to include the present invention in place of the UV light system, carbon filter, and 1 micron filter, and the unit was returned to the same typical office environment (temperature 74 to 78 degrees F., humidity 44 to 56 %, with the following results

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20 DATE	HETEROTROPHIC PLATE COUNT
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8/4/03	46
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8/5/03	NA
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8/11/03	25
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8/25/03

NA

9/15/03

NA